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PERCEPTION OF SPATIAL PATCHINESS BY ANT ASSEMBLAGES (HYMENOPTERA: FORMICIDAE)

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Abstract. The composition of ant assemblages was studied in a sandy grassland in the Kiskunság National Park, Middle Hungary. Ants were sampled with pitfall traps arranged in groups of five at 22 sites. Traps worked from March to November, 2007. The ants represented more than 81 % of the ground-dwelling fauna (104 668 ants out of 130 112 invertebrate specimens). The rank-abundance function of the populations from the whole area fits well the geometric series (psame = 0.99, Kolmogorov-Smirnov test). We could distinguish three groups of species by NMDS ordination: those living on sand dunes, in the deeper moister wind-furrows and pasture, respectively. The average Bray-Curtis similarity of ant assemblages between the sample plots was 0.30, which is significantly smaller than the corresponding null model, whereas the CV of similarities was 0.89, greater than the null model. These figures show that the ants are sensitive indicators of the habitat patchiness and the sample plots are well grouped in the indication by ants. We observed significant correlation of the ants with vegetation architecture and the composition of soil dwelling fauna. The results of the multiple linear correlation revealed that the individual populations differently react to the potential environmental variables.

Keywords: ants, sand-dune grassland, environmental heterogeneity, ecological indication

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Introduction

The interpretations of spatial and environmental heterogeneity have a long tradition in ecology. Starting with the seminal papers by the MacArthur school (MacArthur and Levins 1964, 1967), different approaches have been introduced to study this topic, which has become rather complex in the course of last decades. Although the vast majority of the studies on spatial heterogeneity are based mainly on the vegetation, we can find a diversity of investigations on animal species, groups or assemblages, too. It scopes from behavioural ecology (e.g. the movement of individual animals through different habitat patches, Stern 1998, Sword and Dopman 1999, Brown 2000, Homes *et al*. 2001, Plister and Peacor 2003) to community ecology. In the letter case, the studies employ one taxon-level assemblage as an umbrella group (Andersen et al. 2002, Rainio and Niemelä 2003) and some refer to more than one taxonomic group (e.g. Oliver and Battie 1996, Reyers *et al*. 2000, Kremen *et al*. 1993, Carignan and Villard 2002). These analyses involve not only different taxonomic groups and different approaches, but also different spatial scales from the within-patch structure to landscape patterns.

Ants are especially good objects for both community ecology and monitoring research (e.g. Agosti et al. 2000, Andersen 1990, 1997, Gallé 1999). Their species number is high enough but not unmanageable, the colonizing propagules are easy to distinguish from the colonies already settled, the sampling techniques are not too cumbersome and their ecological indication properties are of middle sensitivity in relation to several environmental conditions. In this paper we analyze the composition and structure of ant assemblages in a sandy soil grassland consisting of small ridges and wind-furrows, performing a small-scale patchiness. Previous, long term (10 years') studies from the 1970s and 1980s demonstrated that ants are mid-sensitive indicators of the spatial heteromorphy in

relation to plants, leafhoppers, real bugs (these are sensitive indicators, with more "coarse-grained response" than ants) and grasshoppers, ground beetles, wolf spider (less sensitive ones, performing "fine-grained" community level response), woodlice, springtails and millipedes (with similar sensitivity as ants, Gallé et al. 1989). Our main goal is to reveal if there are changes in the perception of heteromorphy by ants in comparison with the results of the former studies carried out decades ago.

Materials and methods

The site

The studied site was a sandy grassland at Bugac area of the Kiskunság, in the middle part of Hungary, between the rivers Danube and Tisza (N 46° 41'49.2", E 19° 36' 10.5"). The site is a part of a large pasture of about 6000 ha area. A 2.4 ha part of the studied area was fenced in 1976 and since then a process of secondary succession has been proceeding there from the grazed, *Festuca pseudovina* predominated pasture to more natural grassland types, i.e. open grassland of *Festuca vaginata* on the drier and warmer sand dunes and a closed, more dense grassland predominated by *Molinia hungarica* and *Salix rosmarinifolia* in the wind furrows, respectively. During the last decades, however, the *Molinia* stands have disappeared as a result of the climate change. Another result of the secondary succession is the appearance of poplar and juniper woodland patches at the edge of the fenced plot, near the adjacent forest. A more detailed survey on vegetation changes in the studied site is given by Körmöczi (1989, 1991, 1996).

Sampling

Ants were sampled with pitfall traps arranged on the following way. 22 small sites (referred to as sampling plots hereafter) were selected and each sampled with five traps, which were 1 m apart. The sampling plots were ± randomly selected, 18 were in the fenced plot and 4 in the pasture. The traps were plastic jars of 6.5 cm diameter and 9 cm depth and half filled with ethylene glycol as preservative. In the course of the vegetation's season the traps were exposed 10 times for two-week periods. Ants were sorted from the material then stored in 70% ethanol in the lab and identified on species level.

Out of the potential environmental factors, we measured or assessed the soil water content, soil water capacity, soil temperature at 3 cm depth and soil surface temperature, full vegetation coverage as well as the vegetation architecture (coverage at 5, 15, 30, 50 and 70 cm heights, respectively, the coverage of mosses and lichens and the average vegetation height) and the composition of fauna dwelling the surface of the soil at taxonomic group level.

Data analysis

The sensitivity of the perception of habitat structure was expressed in two ways. We computed the average of Bray-Curtis (B-C) similarities among the sampling plots on the basis of the composition of ant assemblages. Lower the average B-C value, more sensitive the indication of the assemblage in question. The other metric was the coefficient of variation (CV) of the B-C similarities. A high CV value indicates that the similar plots are well grouped in the "copy" of the landscape patterns by the ants. A random reference (null model) with the same numbers of habitats, species and occurrences was used with 1000 replicates to compare the real data with randomly assembled communities.

We applied the Mantel test, with 10 000 replicates (Mantel-2.0 unpublished software), between the matrices of the corresponding distance values to establish the congruence between ant assemblages and the different potential background factors. The correlation between the frequency of the individual species-level populations and the presumed environmental variables was established with model selection based on a multiple linear correlation analysis. Out of the widely used multivariate techniques, we applied the Non-Metric Multidimensional Scaling (NMDS) with Horn index and the cluster analysis to reveal the relative position of the sampling plots on the basis of their ant assemblages. We employed the following packages for statistical treatments: R, PAST, Ms Office and Mantel2.

Results

In the course of the sampling altogether 130 112 invertebrates were collected, out of them 104 668 were ant specimens identified on species level. Therefore, the ants represented more than 81 % of the whole epigeic fauna. The ants belonged to 20 species as follows: *Myrmica schencki* (Emery, 1895) [MSCH]; *Myrmica sabuleti* (Meinert, 1861) [MSAB]; *Solenopsis fugax* (Latreille, 1798) [SOLE]; *Temnothorax interruptus* (Schenk, 1852) [LEPT]; *Tetramorium caespitum* (Linnaeus, 1758) [TETC]; *Anergates atratulus* (Schenck, 1852) [ANAT]; *Tapinoma ambiguum* (Emery, 1925) [TAMB]; *Plagiolepis vindobonensis* (Lomnicki, 1925) [PLVI]; *Plagiolepis ampeloni* (Faber, 1969) [PAMP];

Camponotus vagus (Scopoli, 1763) [CAVA]; *Lasius psammophilus* (Seifert, 1992) [LAPS]; *Lasius paralienus* (Seifert, 1992) [LAPA]; *Lasius niger* (Linnaeus, 1758) [LANI]; *Formica sanguinea* (Latreille, 1798) [FOSA]; *Lasius carniolicus* (Mayr, 1861) [LACA]; *Formica cunicularia* (Latreille, 1798) [FOCU]; *Formica rufibarbis* (Fabricius, 1804) [FORU]; *Formica pratensis* (Retzius, 1783) [FOPR]; *Formica fusca* (Linnaeus, 1758) [FOFU]; *Polyergus rufescens* (Latreille, 1798) [POLY]. The abbreviations in the brackets [] are used in the tables and figures hereafter.

The rank-abundance function of the populations from the whole area fits well the geometric series (D = 0.1; psame = 0.99, Kolmogorov-Smirnov test, Fig. 1).

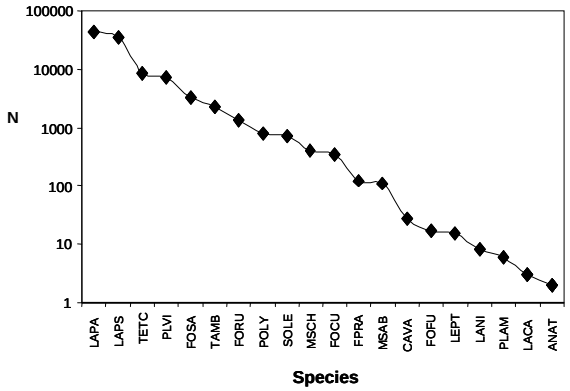

Fig. 1. The rank-abundance curve of the whole ant assemblage

In the NMDS ordination factor space made on the basis of the composition of the ant assemblage es at the sampling plots, three groups can be distinguished (Fig. 2), the pasture (plots 19-22), moister, deeper parts (plots 4 and 14) and the others representing mainly the sand dunes, but some plots of this group are also situated in transitional position between the dunes and the wind furrows, which have become drier during the last three decades as a consequence of climate change (details will be given by Kanizsai et al, in preparation).

The average Bray-Curtis similarity of ant assemblages between the plots was 0.30, which is significantly smaller than the corresponding null model ($p < 0.001$), whereas the CV of similarities was 0.89, greater than the null model ($p<0.001$). The low average value of the similarity shows that the ants are rather sensitive indicators of the habitat patchiness. Owing to the high CV value we can assume that the sample plots are well grouped in the indication by ants, whereas there are considerable differences among these groups, as it is demonstrated by the cluster analysis (Fig. 3).

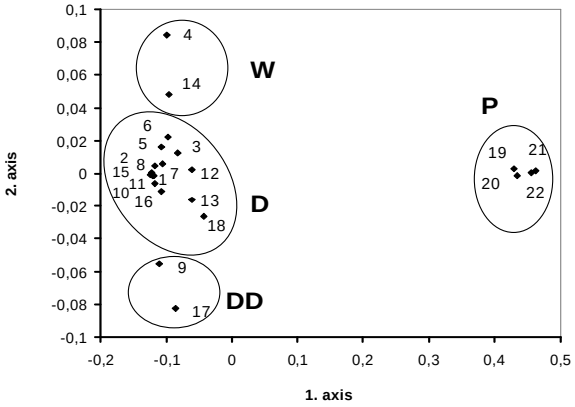

Fig. 2. NMDS ordination of the sampling plots on the basis of the composition of ant assemblages. P: pasture; W: wind furrows, D: sand dunes and transitional plots, DD: degraded dunes.

We observed significant correlation of the ants with vegetation architecture and the composition of the soil dwelling fauna by comparing their similarity matrices and applying Mantel test ($r = 0.22$, $p < 0.0001$ and $r = 0.47$, $p < 0.0001$, respectively). The results of the multiple linear correlation analysis are shown in Table 1. On this basis, the individual

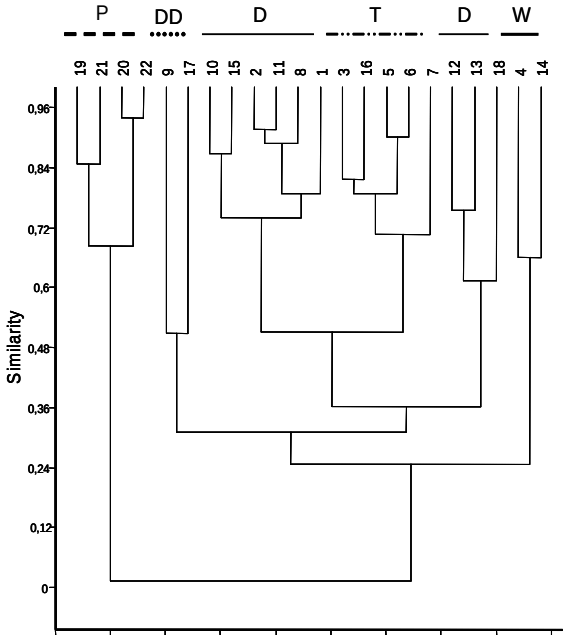

Fig. 3. Dendrogram of the ants assemblages at sampling plots. P: pasture; D: dunes; DD: degraded dunes; T: transitional plots and W: wind furrows.

Table 1. The results of the multiple correlation analysis between the frequency of ants populations and some presumable environmental conditions. The levels of significance: *** p<0,001; ** p<0,01; * p<0,05; - not significant.

	Conditions								
Species	Soil temperature at 3 cm depth	Soil temperature at the surface	Soil water capacity	Soil water content	Vegetation coverage	Mean vegetation heighth	Vegetation coverage between 0-5 cm	Vegetation coverage between 5-15 cm	Vegetation coverage between 15-30 cm
LAPS	-	-	-	-	-	***	-	*	-
FOCU	-	***	-	-	**	-	-	-	-
PLVI	**	-	*	*	-	-	**	-	-
TETC	-	**	-	-	-	-	-	-	***
TAMB	*	**	-	-	***	-	-	-	***
FOSA	**	-	-	-	-	-	-	-	**
FORU	-	***	-	-	-	-	*	*	-
MSCH	**	-	-	-	-	-	-	-	-
MSAB	-	-	-	**	-	-	-	-	**
LAPA	-	*	-	*	**	*	-	**	*

populations differently react to the potential environmental variables, presumed to affect the population and community characteristics of ants.

Discussion

Although the dominance and importance of ants have been demonstrated from several ecological systems (Hölldobler and Wilson 1990, Agosti *et al*. 2000), such a numerical predominance as the contribution of ant to the epigeic fauna described in this paper has not been documented from other types of ecological systems. Such a high proportion was found in other sandy habitats, too in the northwestern part of Hungary (Gallé 2008). As the numerical representation is one of the important conditions for groups suitable for biodiversity monitoring, this fact underlines the applicability of ants for this aims.

The geometrical series are usually regarded as a typical rank–abundance function of such communities which are either at the early primary successional stages or structured by the competition (Magurran 2004). In this case, however, neither hypothesis seems to be valid. Although there is an already rather slow secondary succession in the studied grassland for more than 30 years, but its process is different form the primary seres. The competition hypothesis could stand, but only within the patches and it is well known that the patchiness of the habitat promotes the coexistence of competitors (MacArthur and Levins 1964, Rosenzweig 1979). It is rather probable that the well-known interpretations of the relation between rank–abundance functions are not always right.

The ants performed significant correlations with the structure of vegetation and the composition of soil dwelling fauna on community level, whereas on the level of single species populations, we found also correlations with soil-surface microclimate, vegetation architecture and in less extent with the components of water balance of the soil in the site studied in this paper. The correlation between soil properties and vegetation structure was described by Bestelmeyer and Wiens (2001) and Boulton *et al*. (2005). In other sand dune sites, the vegetation architecture, the epigeic fauna and the soil properties were the external correlates of the ant communities (Gallé 1991, 1999, Gallé *et al*. 1998, Járdán *et al*. 1993).

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